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WEST AFRICAN CACAO RESEARCH INSTITUTE

IMPERIAL MYCOLOGICAL INSTITUTE
MAR 1947

ANNUAL REPORT

April, 1944, to March, 1945

TAFO, GOLD COAST

Published on behalf of the West African Cacao Research Institute by the Crown Agents for the Colonies, 4, Millbank, London, S.W.1.

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WEST AFRICAN CACAO RESEARCH INSTITUTE.

ANNUAL REPORT : 1st APRIL, 1944, TO 31st MARCH, 1945.

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I. INTRODUCTION.

Disturbing reports concerning the spread of cacao pests and diseases in West Africa, coupled with an increased demand for cacao beans—the export of which had once more become fully possible—led the Agricultural Adviser to the Colonial Office, Dr. H. A. Tempany, C.M.G., to visit West Africa and to examine the disease situation on the spot.

Dr. Tempany arrived on the West Coast in October, 1943, and after touring cacao areas both in the Gold Coast and Nigeria had no hesitation in confirming the previous reports concerning pests and diseases. He considered that nothing short of a concerted drive by scientists to investigate these pests and diseases and to devise control measures against them would meet the threat of destruction overhanging the cacao plantations. Disease investigations, limited by shortage of staff and by war-time multiplicity of duties devolving on it, were under way in both Nigeria and the Gold Coast. Though this work was proceeding on a small scale with little co-ordination between the two colonies it was of high quality, and formed a solid basis on which to build and expand further research into diseases and pests.

Original Disease Research Scheme.

With the full support of the Minister of State resident in West Africa and of the Governors of the Gold Coast and Nigeria, Dr. Tempany put into effect a scheme for combating these cacao pests and diseases. This scheme entailed the creation of a team of scientists working on a West African basis under the administrative control of the Resident Minister. The team would be composed of entomologists, pathologists, botanists, chemists and agronomists under a Director of Research. The "would" in the preceding sentence is used advisedly, since it was realized that many months might elapse before the team could be got together. Steps were taken, however, at the earliest moment to second officers from the West African colonies, and efforts were made to recruit specialists from other parts of the Empire.

Taken as an emergency measure solely to combat pests and diseases the scheme would be reconsidered in three years' time with the object of deciding whether it should continue on a temporary basis or whether it should become a permanent research body possibly incorporated into a West African Agricultural Research Institute. For the three-year period minimum capital equipment would be required, and the secondment, as opposed to the appointment of staff, would make unnecessary any immediate decision on the future of the scheme.

The Cacao Research Station at Tafo in the Gold Coast was selected as the headquarters of the research team on account of the excellent laboratories already in existence and on account of its proximity to the

centre of devastation caused by swollen-shoot disease. The station had been created by the Gold Coast Government in 1938 for the specific purpose of cacao research; the duties of the departmental staff posted there were concerned almost entirely with cacao. A full account of this station is given in the Report on the Central Cocoa Research Station, Tafo, 1938–42.

An essential counterpart to the scheme was a survey of the cacao farms in the Gold Coast and Nigeria. Not only was there a lack of knowledge concerning the whereabouts of disease and pests within the cacao belt, but there was also a surprising ignorance as to the position of the cacao areas themselves. This was particularly true of districts where new plantings had not yet come into bearing. Concerning these, there was no information to be gained from figures obtained by produce buyers or inspection staff such as were recorded in areas supporting mature cacao. Even purchase and inspection figures were only of doubtful value since cacao beans were known to be transported often many miles from the source of production to the buying and inspecting centres.

No decision was taken as to the source of funds for financing the scheme, but it was suggested that the Governments might contribute and that sums might be obtained from Colonial Development Funds and from the cocoa manufacturing interests. The surveys would be the financial responsibility of the respective Governments.

To correlate the work of the research scheme and that of the Surveys an Advisory Committee would be set up which would also advise on the direction which research should take.

The Director of Research arrived at Tafo on March 20th, 1944, and in his position of Chairman of the Committee called the first meeting for April 25th, 1944.

West African Cacao Research Institute.

To make this first annual report comprehensible it is necessary to anticipate certain information which will be recorded later in the text.

The original scheme was of short duration. At the first meeting of the Advisory Committee a resolution was unanimously passed that the temporary character of the scheme should be altered to one of permanency at the earliest possible date. This view was summarized at the meeting by the Gold Coast cacao producers' representative, the late Honourable Nana Kwadade II, Omanhene of Akwapim, who said "As long as cacao exists in the Gold Coast there is need for Cacao Research."

Events of a financial nature hastened the possibility of creating a permanent Cacao Research Institute. Profits from the West African Produce Control Board were considered a legitimate source from which to finance the proposed Institute and the initial surveys in both colonies. By July, 1944, the Resident Minister was in possession of a revised draft organization, incorporating certain suggestions concerning staff made by the London Cacao Committee—a body of leading scientists—which placed the scheme on a permanent footing. This draft, somewhat modified, was confirmed by the Secretary of State, and birth was given

to the West African Cacao Research Institute. The birth certificate, in the form of an orthodox constitution, is now awaiting legal registration.

POLICY OF THE INSTITUTE.

The origin of the scheme, and later of the Institute, makes it abundantly clear that research must now be concentrated on pests and diseases which immediately threaten the West African cacao industry. In more specific terms this means making a full investigation into the bionomics of the cacao capsids, *Sahlbergella singularis*, Hagl., and *Distantiella theobroma*, Dist., their parasites, predators and food-plants, and into the virus diseases of cacao and the vectors and alternative host plants of these viruses, with a view to the discovery of practical measures of control.

As a permanent research Institute, priority will be given to those problems which, at the time, most affect the efficiency of West African cacao production.

The Institute is essentially a fact-finding body and has no responsibility for executive action, which is the function of the respective Governments. Pertinent facts, when they become known, will be presented by the Institute to the Cacao Research and Survey Advisory Committee, which will examine them and decide whether the Governments should be advised to take action.

While it is thus easy to define the policy of the Institute towards the Governments, it is more difficult to state categorically where the work of the Institute ends and where the work of the Agricultural Departments begins. These Departments are not merely executive bodies for carrying out a cut-and-dried Agricultural policy, but they are themselves keenly interested in Agricultural research. Cacao as a crop must loom largely in the interests of the Nigerian Agricultural Department and still more so in those of the Gold Coast Department.

At what point does the Institute hand over investigations to an Agricultural Department? There are generally three stages in any particular line of work. First, the laboratory, calling for highly skilled technical staff and specialized equipment. Secondly, strictly controlled field experiments, putting to the test and confirming (or discounting) the observations and deductions made in the laboratory. And thirdly, field experiments under local agricultural conditions in which are tested not only the validity of previous work in the first two stages but also the economic and psychological effects on the farmers. It is only after the third stage that executive action can be taken with confidence.

The ultimate aim of the Institute is to obtain information on which advice can be given for safeguarding and improving the efficiency of production of the West African cacao industry. The stage at which the Institute hands over work to an Agricultural Department must be left to the common sense of both, bearing in mind that the fundamental object is to reach that stage where executive action can most quickly be put into effect. The organization of the Agricultural Department will naturally influence the stage, speed and efficacy at which a line of work,

commenced at the Institute, can be taken over, developed and put into general practice.

It is obvious from this that the stronger and better organized the Departments of Agriculture are, the more benefit will accrue from the work of the Institute. In fact, the Institute without efficient Agricultural Departments will be of little or no value. This is particularly so in West Africa where production is in the hands of peasant farmers who are for the most part illiterate. In this respect there is a marked difference between this Institute and the Rubber Research Institute of Malaya, for instance, which passed on experimental results to highly organized European estates capable of utilizing information and improved planting material with the utmost expedition.

SURVEYS.

In 1944 cacao surveys were commenced in the Gold Coast and Nigeria by the Agricultural Departments of those two Colonies. The immediate objects of these surveys were three-fold : First, to find where the cacao was being grown ; secondly, to note the presence or absence of swollen-shoot disease, and thirdly, to observe the degree of damage caused by Capsids (*Sahlbergella* and *Distantiella*). The fulfilment of these objects will allow prompt action to be taken in adopting disease and pest control measures as soon as these are known, and the information gained may well be of direct value to the Institute.

Indirectly, much further information of importance will accrue from these surveys, and there is little doubt they should bring to light problems in connection with the production of cacao which will require investigation by the Institute.

The discovery of swollen-shoot outbreaks in Nigeria and in districts of the Gold Coast where the disease was previously unrecorded has already been of the greatest value—even if it does further complicate provisional theories on the origin and spread of the virus.

ORGANIZATION OF THE INSTITUTE.

There are four divisions—Entomology, Botany and Pathology, Chemistry and Soil Science, Agronomy. Each is under a divisional head who is responsible to the Director for the day to day running of the division. The general programme of work on pests and disease had already been laid down on broad lines by Dr. Tempany in 1943, and no major alterations have since been called for ; but minor alterations are decided by the Director in consultation with the head of the particular division ; or if wider aspects are under consideration, with other divisional heads.

Much of the work entails close co-operation between divisions and each member of the staff is encouraged to learn what is being done in divisions other than his own.

The need for a Principal Research Officer to give guidance in the details of research to all divisions and to act in the Director's absence has been keenly felt, and it is gratifying to know this post will shortly be filled.

A clearer picture of the organization may be gathered from the following very brief summary of the work undertaken during the past year or shortly to be commenced.

Entomology.

Bionomics of Capsid bugs, their parasites and predators (Investigations both at Tafo, Gold Coast, and Owena, Nigeria).

Insecticides and Spraying.

Toxic action of capsids.

Insect vectors of cacao viruses—in collaboration with the Botany and Pathology Division.

Botany and Pathology.

Cacao virus research.

Theobroma introductions.

Breeding and progeny trials.

Fungal diseases of cacao.

Chemistry and Soil Science.

Mineral deficiencies of cacao.

Soil survey of the West African cacao belt, with particular emphasis on cacao root development according to soil type.

Examination for possible correlation between soil type and the incidence of swollen-shoot disease and capsid attack.

Agronomy.

Experimental replanting of cacao in areas devastated by virus disease.

Experimental maintenance of existing cacao in close proximity to outbreaks of virus disease.

Examination of cacao in native farms with a view to observing clinical symptoms and relative importance of pests and diseases in the field.

Intensive examination of the field results consequent on the cutting-out policy of the Agricultural Department for the control of swollen-shoot disease.

Observations on methods designed by certain farmers to control swollen-shoot and capsids, and to assess the scientific value of such methods.

Station.

Upkeep of experimental plots and habitation area.

Accounts and Correspondence.

Supervision of new constructions.

The amalgamation of the Botany and Pathology sections into one division is copied from the Department of Agriculture, Nigeria. The amalgamation in that Colony brought many advantages both from the technical and administrative aspects, but the time may shortly come when it will be advisable to reconsider this amalgamation.

The formation of an Agronomy Division calls for some comment. It was brought into being to fill the gap between research and practice. Normally the work of this Division might well be part and parcel of the functions of an Agricultural Department, but owing to war-time activities and shortage of staff the Agricultural Department of the Gold Coast was not in a position to undertake this work.

The warm approval accorded to the formation of the Division by the West African Cacao Research and Survey Advisory Committee has been justified. Already the examination of outbreaks of swollen-shoot infected cacao cut out by the Agricultural Department has yielded a mass of definite information on the value of this method of control. The cutting-out policy had been allowed to lapse since 1943 on account of staff shortages and war-time priorities.

The West African scope of the Institute has created particular difficulties in connection with officers travelling between and within Colonies. Light lorries, suitable for undertaking these often extensive tours, have been unobtainable by the Institute, and the hire of such vehicles has been expensive and unsatisfactory. Not only the officers themselves but their servants and technical staff have to comply with all the complicated regulations concerning passports, visas, exit permits and currency forms, when passing from one British Colony to another. The advantages of air travel are counterbalanced by the disadvantages of arrival without personal luggage and servants.

Surface and air mail facilities between Nigeria and the Gold Coast have been far from satisfactory and considerable delays are common. No doubt these difficulties will be lessened, and one may look forward to direct telephone or radio communication between the main West African centres.

European Staff.

The staff list is given on page 4 of this report.

It is unnecessary to stress the difficulties that have arisen in obtaining European staff. Without the co-operation of the West African Governments in seconding officers to the Institute, and without the unceasing efforts of the Colonial Office to recruit others, this Institute could not have come into being at this time.

Additional to four officers of the Gold Coast Agricultural Department earmarked for or working mainly on cacao at Tafo prior to the inception of the research scheme, the Gold Coast Government has seconded a further four. To offset this, one officer (the Senior Entomologist), also formerly working on cacao, has remained in the Department to carry out research in other directions.

The Nigerian Agricultural Department has released one officer and is shortly to release another. The Sierra Leone Agricultural Department has seconded one officer.

There have been four new appointments, two of whom have had considerable experience elsewhere in their particular fields of research. The total number of European staff at the end of the financial year is fifteen.

It will no doubt be appreciated that many of the staff possessed little, if any, knowledge of cacao before their arrival at Tafo. In order to gain a general perspective in regard to the crop, encouragement has been given to officers to visit districts where certain aspects of disease, damage by pests, or local cultivation practice, warrant particular notice.

There is the tendency to compare the staff requirements of the Institute with that of Colonial Departments. This comparison often discounts the expanse of territory over which the Institute functions and the corresponding length of time taken during tours of investigation. This in turn means long absences from headquarters and a staff larger than might be required were the work confined to laboratories.

The present establishment, which is incomplete, does not make allowance for the fact that the Senior Chemist, who is included in the 15, works part-time for the Institute and part-time for the Department of Agriculture. This arrangement, made out of necessity since no other Agricultural Chemist was available, has only been made possible through the willingness and understanding of the Senior Chemist himself.

African Staff.

At the commencement of the scheme fifteen pensionable African staff who had been working under the Agricultural Department on cacao research were seconded to the new organization. In most instances they continued the lines of work on which they were previously engaged, and they have formed a most valuable nucleus for the subsequent expansion of the establishment.

Recruitment of new staff has been difficult—not because of the scarcity of applicants but because of the poor quality of their scholastic attainments in biology or chemistry. Not unnaturally the best students from the colleges had already been earmarked for other technical departments, of which the Medical is perhaps the most popular. The Institute has therefore had to recruit from among those with poorer qualifications. To overcome this in the future it has been found necessary to raise the initial salary and to make prospects in the W.A.C.R.I. organization more attractive. There are no longer in the Gold Coast any facilities for scientific Agricultural training such as exist in the Nigerian Agricultural Department's school at Ibadan.

Several of the Gold Coast Department of Agriculture's non-pensionable staff have been promoted to the pensionable establishment of W.A.C.R.I.; the total number of pensionable staff, including probationers, is now thirty-four. Further recruitment will be necessary, and consideration will be given to the possibility of sending certain of the staff for further training to schools or colleges outside the Gold Coast.

With effect from April 1st, 1945, the revised African staff grades and salary scales stand as follow :—

Assistant Specialists	...	Under consideration.
Senior Technical Assistants	...	£222–12–282.
Technical Assistants	...	£60–6–78; 90–8–138; 154–10–208.

The same salary scales are applicable to Accounting and Clerical staff.

More attractive salary scales have been introduced for the non-pensionable staff. There are a number among these who are experts in their own particular work but who have not the necessary qualifications for promotion to the pensionable staff. The maximum non-pensionable salary is £120. Although these Assistants are on an incremental scale, the actual amount of the increment is decided by a committee which meets annually in March.

Scientific Co-operation.

It is the Director's desire to express on behalf of the Institute the warmest thanks to those scientists who have visited Tafo and given the benefit of their advice. Dr. H. H. Storey, Amani, at considerable inconvenience, came in November, 1943, to examine the work which was then in progress on the insect vectors of swollen-shoot disease. He offered valuable suggestions, many of which have now been put into practice; others will be incorporated in the programme when the necessary stage of progress has been reached.

Professor Buxton, of the London School of Tropical Medicine and Hygiene, gave up-to-date information on D.D.T. and on certain other insecticides during a visit from Takoradi to Tafo undertaken specifically for this purpose. The specialized knowledge which he placed at the disposal of the Institute will be of the greatest use.

Dr. Ripper, of Pest Control Limited, arrived from England in November, 1944, and during a stay of two weeks accomplished much in carrying out investigations of sprays and insecticides, in co-operation with the Entomological staff. Thanks to the interest he has taken in the chemical control of capsids, the Institute now has considerable knowledge of this subject which will be put to good use when the spraying equipment arrives.

A committee of leading scientists has been formed at the instigation of Dr. Tempany to advise on Empire organization of research on cacao and on other matters pertaining to that crop. This committee, which meets in London, is kept fully informed of the Institute's work through its quarterly and other reports.

Among these scientists are the heads of the Imperial Agricultural Bureaux in England and to them and to their Bureaux the Institute owes a debt of gratitude for assistance, particularly in connection with the classification of insects and plants.

West African Cacao Research and Survey Advisory Committee.

When W.A.C.R.I. was still a Cacao Disease Research Scheme the members of this Committee comprised the following:—Directors of Agriculture, Gold Coast and Nigeria; Chief Conservators of Forests, Gold Coast and Nigeria; Gold Coast representative of Cocoa Manufacturers; Gold Coast representative of cacao producers; representative of Resident Minister's Office; Chairman, the Director of Research.

In the course of the year the Committee was augmented by one Senior Political Officer each from the Gold Coast and Nigeria, by a representative of Cocoa Manufacturers from Nigeria and by a cacao producer from that colony.

The terms of reference of the Committee were to advise the Director on matters connected with research and administration and to correlate research with the Surveys.

The first meeting, from which the Nigerian members were unfortunately absent, took place on April 25th and 27th, 1944. The members agreed to take on the duties of a finance committee. They approved the general organization as described by the Director and urged that the scheme should be made permanent.

The Committee at its second meeting on December 5th, 1944, again lost the benefit of the Nigerian members, though one was able to be present on the second day. The research work in progress was examined, and the revised estimates of expenditure considered. Useful advice was rendered on numerous subjects ranging from land acquisition to the insurance of labour. The Committee urged that steps should be taken to obtain a legal constitution for W.A.C.R.I. (as the Scheme had then become).

The third meeting was held on March 22nd, 1945, and Nigeria was well represented. Unfortunately both the African Producers' representatives were unavoidably absent. This meeting was mainly concerned with the 1945/46 estimates for the Institute and for the Surveys.

There is no doubt that the Committee has filled an essential need ; the time accorded by the members to the interests and welfare of the Institute has been greatly appreciated.

Training of Survey Staffs.

One of the first functions of the Institute was to train Nigerian Agricultural staff in the diagnosis of diseases and insect damage. One hundred and twenty-five Nigerian African Assistants underwent this training at Tafo. Each course lasted six days, the Assistants arriving from Nigeria in groups of fifteen to twenty. Thanks to the good organization of the Nigerian Department, the training scheme worked smoothly and the first discovery of swollen-shoot disease in Nigeria by one of these Assistants gives confidence that the courses were of practical use.

The need for training Gold Coast staff in disease diagnosis was not so acute because many were familiar with swollen-shoot symptoms. None-the-less, all the African survey staff were given short courses at Tafo.

Particularly interesting was the decision of the Nigerian Government to send a party of chiefs from the main cacao producing areas to see for themselves the devastation that swollen-shoot disease can cause. This party, under the guidance of a Senior Nigerian Political Officer, spent several days at Tafo and were shown the havoc that would descend on the cacao farms of their own country should swollen-shoot disease spread unchecked. It is understood that these chiefs appreciated the threat to

their people's welfare, and have been most helpful in explaining to the Nigerian cacao farmers the reason why the Department was carrying out the survey.

Land, Buildings and Equipment.

The land on which the experiment station was established in 1938 is being loaned during His Majesty's pleasure to the Institute. An additional one square mile of land for experimental purposes has now—after some nine months of negotiation—been acquired by the Gold Coast Government and will similarly be loaned to the Institute. Permanent buildings, which include five bungalows, laboratories, office block and sundry other buildings, are being purchased from Government at cost price. Non-consumable equipment is also being paid for at cost price. One bungalow has been purchased from Messrs. United Africa Company Ltd. and one has been made available through the generosity of Messrs. Cadbury and Fry.

Details of new construction will be found later in the report.

Indents for equipment were submitted in July, 1944, and are now beginning to arrive. Perhaps the most important item was wire gauze for the new insectaries, and the Institute was fortunate to obtain this within eight months. The delay in delivery of spraying equipment has meant that serious work on sprays has been impossible. Shortage of dissecting microscopes has also handicapped investigations undertaken by the Entomological Division. Shortages of building materials have been acute, and the Officer-in-Charge of the station has had no easy time in carrying out the building programme.

A large indent for current and back numbers of scientific journals has been submitted. Many of these are in short supply, and it is probable that there will be a heavy demand for them in order to replenish the devastated libraries of Europe.

Health.

The fact that there have been eight hospital cases of W.A.C.R.I. European staff during the twelve-month period presents a gloomy picture. Most of the staff have been on the sick list for varying periods. During the past six months there have been five women and five children on the station, and most of these have also been under medical attention. Apart from two cases of amoebic dysentery and two of nervous disturbance the main causes of sickness have been "Sandfly fever"—not a fatal but a very debilitating disease—and malaria.

The Institute has had the benefit of advice from the Area Malariologist, and contour surveys, one mile in radius from the habitation area, have now been made with a view to possible drainage schemes. But the trouble is more than drainage alone is likely to cure. New Tafo town is within half a mile of the habitation area and no doubt is a constant source of infected mosquitoes. There are small native compounds within a few hundred yards of the European bungalows and these compounds probably also serve as focal points for infection. Now that the one

square mile has been acquired these native compounds are being removed. A constant source of mosquito breeding occurs in damaged cacao pods and their husks after breaking. Strict control of such breeding places has been kept on the Institute's own cacao plots, but no such control has been practicable on surrounding native farms. The new acquisition, over which the Institute will now have control, should therefore no longer be a reservoir for either mosquitoes or malaria.

Unfortunately there appear to be no known means of overcoming the sandflies or the fever they are assumed to transmit.

The constant assistance and supervision given by the Health Department has been greatly appreciated.

Proposals for bringing pipe-borne water to the Institute are under consideration. During the past year all water has been supplied from rain-water tanks and wells, but an acute shortage developed in the dry season.

It is the intention of the Institute to adopt all measures for the maintenance of health which have been proved successful in other tropical countries. War-time shortages make immediate adoption of many of these measures impossible.

General.

The first few years of the Institute will of necessity be difficult, all the more so because of the inevitable shortages of staff and equipment during this period of world uncertainty. Many of the staff have been with the Institute less than six months and during this period they have had to work with a crop which was new to them and under improvised conditions. All the more credit is therefore due to the research team for the excellent progress made in this, the first year of W.A.C.R.I.

Co-operation with the French West African Colonies.

It has been a pleasure to have had visits of scientists from French West African territories. From the French Cameroons, M. Pascalet, Director of Agricultural Research, came to Tafo with certain of his African staff and acquainted himself with the latest work on swollen-shoot disease. He has left a valuable report on the cacao in the French Cameroons, and it is interesting to note that the disease has not yet been recorded from that area in spite of extensive search.

M. Alibert, of the Ivory Coast Department of Agriculture, has made several visits to Tafo, and the control measures against swollen-shoot adopted in the Ivory Coast are based on information given freely by the Institute. In return, one of the W.A.C.R.I. officers has visited the Ivory Coast and his report on the disease situation in that colony has been most instructive.

Although little cacao is grown in French Togo, reciprocal visits have been made between staff of the Institute and Togo Agricultural Officials.

French scientists from Dakar and the Inspector-General of Agriculture for the French Colonial Empire have taken a keen interest in our work during their visits to Tafo.

Co-operation with the Belgian Congo.

An entomologist, returning from S. Africa on the expiration of his leave to take up his duties at Tafo, visited the Belgian Congo with a view to making contacts with the Department of Agriculture and with INEAC.* Information of importance on cacao capsids was freely given by officers of these organizations, and the offer of future co-operation is warmly welcomed.

Acknowledgements.

It will have been noticed in the preceding paragraphs that generous help has been accorded to the Institute at all levels wherever problems of science or administration arose. Special reference, however, must be made to the part played by the Gold Coast Government in seconding European and African staff to the Institute and in advancing funds which have made possible the development of W.A.C.R.I.

If these acknowledgements are brief, it is because the Director believes that those who read this report will be more interested in W.A.C.R.I. and its work than in the contributions of those who have helped to establish an organization the success or failure of which may influence the structure of future Colonial Research Institutes.

II. VIRUS RESEARCH.

Most of the year's work has been a continuation and expansion of the programme which has occupied the Department of Agriculture since 1937 and which has been published in the " Report on the Central Cocoa Research Station, Tafo, 1938–42."

Strains of the Virus.

Within a short time of the discovery of the virus nature of swollen-shoot disease it was appreciated that markedly different symptoms existed, and that these differences were in all probability due to different strains of the virus. Thus the disease in the Bisa area of the Gold Coast was typified by very large swellings on the stems but by little disturbance in the leaves and apparently by no debilitating effect on the tree itself. But in the New Juaben area, stem swellings were not so marked, though characteristic leaf symptoms were apparent and the disease caused rapid death to the tree.

The differences in these symptoms were maintained when healthy plants were infected by budding with the two strains. Swollen-shoot disease discovered in new areas has frequently been characterized by a new set of symptoms, and there is now firm evidence that a number of strains of the virus exists. It is of interest to note that two such strains have not yet been observed to cause any stem swellings at all.

It is desirable to obtain as precise a classification of each of these virus strains as possible. To do this uniform clonal material is necessary, and a technique must be evolved for the transmission of each specific strain. The usual method of doing so in virus work is by means of specific insect vectors, and we hope to be able to employ this method in due

* L'Institut National pour l'Etude agronomique du Congo Belge.

course. An exact knowledge of the strains will materially assist work on immunisation, resistance and alternative hosts.

Table 1 gives such information as we have on the characteristic symptoms produced by eight strains. The symptoms recorded are based on close observation of infected trees in the field and on plants grown at Tafo after transmission of the virus by budding. Thus the possible influence of environmental factors on the type of symptom has been largely avoided. It must be noted that the index is of a provisional nature, and that future work may well disclose further strains or may even reduce the number. We have as yet no positive information that strain A is, in fact, a single strain, though for immediate purposes it may be regarded as such.

TABLE 1.

SYMPTOMS OF VIRUS STRAINS.

A = New Juaben. C = Kpeve. E = Pamen. G = Dochi.
B = Bisa. D = Nkawkaw. F = Wiawso. H = Dawa.

Strain.	Virulence.	Leaf Symptoms.		Stem Symptoms.	Latent Period (days).	
		Acute.	Chronic.		Leaf Symptom.	Stem Swellings.
A.	+++	Vein-clearing. Red vein-banding. Mosaic.	Small, pale leaves. Occasional yellow vein-banding (fern-pattern). Necrosis.	Swellings. Die-back.	120	150
B.	—	Slight chlorosis.	None.	Swellings (large).	—	118
C.	+	Vein-clearing. Red mottle.	Yellow mottle. Necrosis. Crinkle. Dark green vein-banding.	None.	114	—
D.	+	Red mottle Yellow flecking.	Occasional yellow vein-banding.	Swellings (slight). Stunting.	120	360 (or more)
E.	+	Yellow flecking.	Yellow mottle (oak-leaf). Red vein-banding (faint).	Swellings (medium).	148	300
F.	++	Red vein-banding. Vein-clearing.	Yellow vein-banding.	Swellings (large). Die-back.	124	360 (or more)
G.	—	Red vein-banding (faint).	Yellow vein-banding.	None.	360 (or more)	—
H.	+++	Red vein-banding. Vein-clearing.	Mosaic. Necrosis.	Swellings. Die-back.	58	100

Virulence symbols :— — = No visible effect on health.
+ = Reduced leaf production and stunting.
++ = Defoliation, slow die-back, premature death.
+++ = Defoliation, rapid die-back, death usually in 2–3 years.

Behaviour of Virus Strain A.

Our knowledge of this virus A—the virulent strain which has accounted for so much destruction in the Eastern Province of the Gold Coast—has been expanded during the year. Out of a large population of healthy mature trees infected by budding with strain A, 44 per cent. of the trees were dead 18 months later and the remainder are in poor health and expected to die within the next few months. Inoculation of healthy trees with either of the mild strains B or C failed to confer immunity when strain A was budded on them one year later.

Evidence has been obtained on the rate of movement of virus strain A in the plant. By amputating the stock immediately below the infecting graft, at successive intervals of time, it has been shown that the virus moves from the infected scion into the stock in less than 24 days.

Attempts have been made to evolve a rapid diagnosis of the presence of virus strain A by a staining technique similar to that employed by virus research workers in America. Results so far obtained indicate that the presence of strain A can be quickly confirmed by staining, but the method is not as yet completely reliable. It is perhaps of interest to record that virus strain C behaves, on staining, quite differently from strain A.

Ring barking experiments have shown that the virus strain A is not usually carried in the xylem in spite of the effects on this tissue, *e.g.*, the actual swellings and the reaction to stains.

Seed Transmission.

No transmission by seed of the virus strains A, B or C has yet been obtained. From a total of 7,278 seedlings taken from infected trees none has shown virus symptoms. In certain instances a marked dwarfing of the seedlings has been noticed, but when grafted on normal healthy seedlings no transmission of this dwarfing characteristic took place. Further trials are in progress.

Insect Transmission.

Investigations on the insect vectors of swollen-shoot disease were delayed until properly constructed insect-proof houses had been built and until the Entomologist specially recruited for this all-important work had taken up his duties. It was decided that the first groups of insects to be tested should include those about which there had been some divergence of results recorded by previous workers. The possible vectors under trial are: the psyllid *Mesohomotoma tessmanni* Aulm., the aphid *Toxoptera aurantii* Boyer, and the mealybugs *Pseudococcus exitiabilis* Laing, and *Ferrisia virgata* Ckll. Five strains of the virus, strains A, B, C, D and F, are being used for testing psyllids and aphids, and three strains, A, C and F, for testing *Pseudococcus* and *Ferrisia*. After the insects have fed for varying periods on the infected plants they are transferred as entire colonies to the healthy receptor plants. This report only covers the initial stages of the test, and it is too early for results.

Resistance to Swollen-shoot Disease.

The selection of isolated healthy trees in farms devastated by swollen-shoot disease has continued, bringing the total number of these up to 452. Budwood taken from them has been propagated at Tafo or at Akwadum and then infected with the virulent strain A. A very high percentage succumb and are discarded, but certain selections, of which there are five outstanding, show only a slight check in growth after infection ; normal growth then follows. These five clones are being propagated as rapidly as possible by budding, and it is interesting to note that the first growth from the bud shows marked mosaic leaf symptoms while subsequent flushes appear normal. Nevertheless, examples have occurred where certain individuals of these clones have succumbed completely to the virus.

Mass infection started in 1942 on over 2,000 mature Trinitario trees at Wiawso and Peki are beginning to reveal differences in tolerance to the disease ; budwood from 16 of these has been taken to Tafo for further trial.

None of the recently introduced varieties of *Theobroma cacao* L. or of the closely related species has yet been tested for tolerance or immunity to swollen-shoot disease. On African farms in the New Juaben area the Agronomist has made most interesting observations which call for closer examination at the Institute. Swollen-shoot was discovered in a certain farm in 1936 and the Agricultural Department cut out the infected trees at about 18 inches from the ground. An examination eight years later reveals that a large number of these stumps had died, but several have survived, giving rise to suckers which are now in bearing. These regenerated trees invariably show mild swollen-shoot symptoms. Moreover, in certain other farms where the disease has destroyed most of the trees farmers have on their own initiative replanted cacao. Many of the young plants in due course became infected and died, but a few are found which have maintained themselves in reasonable growth in spite of the fact that they show mild symptoms on the leaves.

We have therefore good evidence that tolerance to swollen-shoot does exist, but we do not yet know the mechanism by which tolerance works.

Alternative Hosts of Swollen-shoot Disease.

Previous work has given no conclusive evidence that any indigenous plants are susceptible to the virus. But the only method available for testing possible nosts has been by the technique of grafting. Once knowledge has been gained on the insect vectors of the virus it will be comparatively easy to use them in attempting to transmit the disease from cacao to indigenous plants and back again to cacao. All we know now is that both *Cola acuminata* and *Bombax buonopozense* develop virus-like symptoms after grafting to infected cacao, but the virus has not been transmitted back from these species to cacao.

Occurrence of Swollen-shoot Disease.

As a result of the surveys carried out by the Agricultural Departments of the Gold Coast and Nigeria, the areas where swollen-shoot can be found have been extended in the former territory and discovered for the first time in the latter. So far as is at present known the swollen-shoot outbreaks in Nigeria are small and confined to Oyo Province. The particular strains of the Nigerian virus are under examination at Tafo.

A pathologist visited the Ivory Coast and concluded that the disease, though widely distributed in the east of that territory, accounted for less than 200 acres. Apparently there are three strains of the virus in the Ivory Coast, two of which are similar to strains A and F.

An entomologist, while examining cacao capsids in Sierra Leone, failed to discover any signs of virus disease. Also apparently free from the disease are French Togo, French Cameroons and Equatorial Africa.

A virus disease of cacao has, however, been reported from Trinidad, B.W.I.

Control of Swollen-shoot Disease.

We have two sources of information concerning the control of swollen-shoot disease by cutting out. One of these is derived from an examination of infected areas which were cut out by the Department of Agriculture, Gold Coast, between 1936 and 1943, the other is derived from observations made on the experimental station at Tafo.

The early attempts near Akwadum in 1936-37 were not successful because the symptoms of the disease were not fully known. A number of trees which we can now recognize as being infected was left in the farms, and the disease continued to spread rapidly in that area. Between 1941 and 1943 the Department cut out diseased trees in the Kwaben areas. Not only were the trees cut below ground level, but also a varying number of apparently healthy contact trees were removed. In certain instances the trees were sprayed with Nicotine sulphate to destroy possible insect vectors.

Owing to shortage of staff the Department was unable to continue these control measures nor could an examination be made to see whether they had been successful. In 1944 two agronomists seconded to W.A.C.R.I. were sent to make detailed observations on these treated outbreaks. They reported that out of 75 such outbreaks near Kwaben 62 were free from infection ; at eight, one diseased tree only was found ; the remaining five contained 62 diseased trees.

Cutting out infected trees and apparently healthy contact trees had successfully eliminated the disease from 76 per cent. of the outbreaks where there were less than ten infected trees, and from 30 per cent. where there were ten or more.

Eighteen of the outbreaks had been re-treated on one or more occasions after the reappearance of the disease. Fifteen of these re-treated outbreaks showed no sign of the disease two years later.

In the Kwahu district re-inspection and re-treatment had been more effective than treatment followed by neglect. Unfortunately, no reliable information could be obtained on the effect of insecticidal spraying.

On the experimental station at Tafo a routine control of swollen-shoot disease has been practised. Every tree in 60 acres is examined each month and infected trees are cut out. Up to 1944, apparently healthy contacts were also removed, but during the past year only those showing symptoms have been destroyed.

The number of infected trees cut out each year (March to February) is as follows :—

1939–40	 54	
1940–41	 394	
1941–42	 147	
1942–43	 133	
1943–44	 136	
1944–45	 170	Total 1,034 trees.

This represents an area of approximately one and a half acres. In the course of the past six years we have consequently lost through disease 2·5 per cent. of the 60 acres. A sample survey of the new one square mile acquisition, which is contiguous with the station and contains cacao of a comparable age, has shown that 23·5 per cent. of the mature trees are dead or infected with swollen-shoot. Except for a narrow strip adjoining the station, no control measures had been practised in the one square mile. The first recorded incidence of swollen-shoot on the station was in December, 1938, and there is reason to believe it invaded the one square mile about that time. Within a period of seven years the loss of trees through disease has been ten times less where control by cutting out has been adopted.

But it will be noticed that new outbreaks are constantly occurring on the station. These are located apparently at random and arise irrespective of the season. For the most part they consist of single trees.

Replanting after cutting out Diseased Trees.

At Akwadum, 16 miles from Tafo, an area of 25 acres of cacao dead or heavily infected with swollen-shoot was taken over by the Department of Agriculture in 1941. The remaining cacao trees were cut out, together with all forest trees, and sixteen acres were set aside for re-establishment trials. After suitable shade had been established cacao was sown at stake in 1942. Establishment has been excellent except in those areas where annual crops had been grown subsequent to the death of the cacao and before the Department took over the land. Only one seedling out of approximately 32,000 has become infected although the area is in close proximity to farms devastated by swollen-shoot. The infected plant was rogued.

On the Institute's station at Tafo the disease has not been recorded on a single cacao tree planted since 1939 in spite of the fact that vacancies caused by cutting out infected trees are immediately filled with seed or seedling supplies.

III. CAPSID RESEARCH.

The two capsids most seriously affecting cacao in West Africa are *Sahlbergella singularis*, Hagl., and *Distantiella theobroma*, Dist. In general the former species attacks the shoots and pods of mature cacao, while the latter confines its activities mainly to young trees, although it also attacks pods. Other species of capsids, notably *Bryocoropsis* and *Helopeltis* spp., are not so important by comparison with *Sahlbergella* and *Distantiella*, although at times they cause considerable pod damage and consequent reduction of crop.

In planning research to lead to practical control of *Sahlbergella* and *Distantiella* it was appreciated that first and foremost the bionomics of these two species must be thoroughly explored. During the year under review the Entomological Division has concentrated on this work both at Tafo and in Nigeria. Thanks to the co-operation of the Department of Agriculture of that territory, the Institute has been able to station an entomologist and assistants at Owena, which is situated within that part of the Nigerian cacao belt most seriously affected by capsids. The Department's experimental cacao farm at Owena, planted in 1934, has, in fact, suffered from the capsids to such an extent that the experiments have been vitiated.

Bionomics of Sahlbergella and Distantiella.

Nature of damage to cacao.

The precise nature and cause of the damage done by *Sahlbergella* and *Distantiella* to cacao have been investigated. The following summary refers to both capsids, the reaction of the cacao being similar. The proboscis, which in the adult is some 1·8 to 2·2 mm. in length, enters the axis of the plant at a right angle, but may then turn sharply. The tissues mainly exploited are the cortex, phloem, cambium and less frequently the xylem. Stained sections of newly damaged tissues failed to reveal any sign of pathogens. We must therefore accept the conclusion that, though certain mechanical damage takes place during feeding, the main cause of necrosis is due to toxic saliva injected by the proboscis. This has always been the accepted theory, but it is important to have confirmation that pathogens are not concerned at the time of feeding. Nevertheless invasion by a fungus, *Calonectria rigidiuscula*, (Berk et Brme.) Sac., into capsid-damaged tissue has been recorded, and work is in progress to assess the part this fungus plays in the formation of cankers.

When *Sahlbergella* feeds the first symptom to appear is a water-soaked area which soon becomes depressed owing to the collapse of the underlying tissues. The younger the shoot the more rapid and extensive the damage. With capsid damage of young green shoots the area around the puncture turns black in a few hours and the shoot often dies. Older shoots that have turned brown are more resistant and can withstand numerous punctures without being killed outright.

The damage is persistent and progressive. Whereas in the case of cortical tissue damaged mechanically the dead tissue is thrown off and new, smooth bark formed, in this case the bark splits some three weeks

after the puncture is made and grows rougher and more cankerous with the passage of time.

Investigations carried out on three-year-old potted cacao plants on which either *Sahlbergella* or *Distantiella* were caged for 24 hours showed that the maximum amount of damage was done within the first two days ; thereafter up to 30 days there was no apparent increase in the area of the damaged tissue, suggesting that the direct action of the toxic substance injected at the time of feeding is soon spent.

Life History of Sahlbergella and Distantiella.

Literature previously published contains much information on the life histories of these capsids, but it was considered advisable to repeat and extend these investigations so that fuller data could be obtained throughout the year. Less extensive records of *Bryocoropsis* and *Helopeltis* have also been made.

As far as possible all life cycle figures have been obtained under field conditions except in the case of adult longevity and oviposition.

TABLE 2.

DURATION OF LIFE CYCLE IN DAYS FROM EGG TO ADULT.

Species.		Incubation Period.	Nymphal Instars.				
			1st.	2nd.	3rd.	4th.	5th.
S. singularis...	Maximum	21	8	7	6	7	8
	Minimum	13	3	3	3	3	3
	Mean	17·4	4·5	4·8	4·5	4·7	5·2
D. theobroma...	Maximum	18	8	6	6	6	8
	Minimum	13	2	2	3	2	2
	Mean	15	4·4	4·2	4·3	4·2	4·8

The maximum and minimum life cycle from egg to adult for *Sahlbergella* was 46 and 35 days respectively and for *Distantiella* 41 and 31 days. The mean cycle for *Sahlbergella* was 40·8 days and for *Distantiella* 36·6 days.

Large variations in the various stages were found to exist, and an examination of all figures up to the present seems to indicate that these variations are connected more with particular batches of eggs than with any climatic or seasonal factor.

TABLE 3.

LONGEVITY IN DAYS OF MATED FEMALES.

		Prematurity Period.	Total number of eggs laid.	Longevity.
S. singularis	Maximum	10	192	42
	Minimum	5	5	9
	Mean	7·1	46·4	21·3
D. theobroma	Maximum	11	106	33
	Minimum	4	6	8
	Mean	6·1	32·3	19·1

TABLE 4.

LONGEVITY IN DAYS OF UNMATED ADULT FEMALES.

Species.		Prematurity Period.	Total number of eggs laid.	Longevity.
S. singularis	Maximum	15	176	49
	Minimum	5	8	10
	Mean	8·6	44·7	22·8
D. theobroma	Maximum	11	47	40
	Minimum	4	4	7
	Mean	7·5	23·6	19·1

Owing to the artificial conditions under which the figures in Tables 3 and 4 were obtained, too much reliance should not be placed on the minimum and mean figures since slight damage may have been caused to the insects during transference from one day's food supply to another.

TABLE 5.

LONGEVITY IN DAYS OF ADULT MALES.

Species.	Maximum.	Minimum.	Mean.
S. singularis	19	3	9·8
D. theobroma	17	2	9·3

Both species feed readily during nymphal and adult stages, so that the females of both species have a potentially destructive life of about sixty days.

Population Studies.

Capsid collections were made twice a week by a standardised method from July, 1944, to March, 1945. The figures for *Sahlbergella* are, of course, influenced by the presence or absence of pods on the trees ; so far no reliable method has been evolved to determine accurately the population, and seasonal variations, of *Sahlbergella* in the cacao canopy above hand's-reach.

TABLE 6.

Four-weekly Period Commencing	*SAHLBERGELLA.*		*DISTANTIELLA.*	
	Total.	Number per 100 trees.	Total.	Number per 100 trees.
1944.				
July 31st	2,840	13·2	2,928	20·9
August 28th... ...	3,938	17·8	3,094	27·1
September 25th ...	6,495	32·3	3,468	42·6
October 23rd ...	9,527	51·7	5,664	54·7
November 27th ...	11,942	64·3	6,650	67·4
December 25th ...	9,836	68·0	7,159	104·4
1945.				
January 22nd ...	10,023	78·5	14,191	157·2
February 19th ...	7,051	57·1	6,782	72·6
March 19th	2,851	26·3	3,490	46·3
April 16th	1,533	14·6	3,613	44·7

Flight Range.

Experiments were carried out with some 5,000 adult *Sahlbergella* and 2,300 *Distantiella*. The insects were released in an open space 8 feet above ground, and it appeared that there was no difference in the flight ranges of the two species. With both, the longest flight of those recovered was about 240 yards.

Control Measures against Capsids.

Biological Control.

Except in so far as we have accumulated knowledge on the bionomics of *Sahlbergella* and *Distantiella* we are no further forward in finding and introducing a new parasite of either of these two capsids. Arrangements have, however, been made for an entomologist to visit Sierra Leone and the Congo with this in view. The cacao in Sierra Leone, though covering only a small area, is reported to be little troubled by these capsids, and it is just possible that some parasite is keeping them in check. More information is being sought on the alternative host plants of *Sahlbergella* and *Distantiella*.

Natural Predators and Parasites.

Standardised weekly routine dissections of *Sahlbergella* and *Bryocoropsis* were made at Tafo and the percentage of parasitism by *Euphorus sahlbergellae* determined. *Euphorus* has not been recorded as a parasite of *Distantiella*.

TABLE 7.

PERCENTAGE PARASITISM BY EUPHORUS.

	S. singularis.	*B. laticollis.*
1944.		
July	8·0	15·0
August	9·4	10·0
September	7·0	6·5
October...	9·0	6·5
November	12·8	6·6
December	14·8	12·0
1945.		
January	17·5	9·5
February	31·0	15·2
March	25·0	13·2

Euphorus is in turn parasitised by *Mesochorus melanothorax* as shown by the following table.

TABLE 8.

PERCENTAGE PARASITISM BY M. MELANOTHORAX.

	Euphorus in S. singularis.	*Euphorus in B. laticollis.*
1944.		
November	18·0	7·7
December	16·1	9·8
1945.		
January	8·5	10·5
February	14·0	7·7
March	14·4	Nil

It is difficult to assess the value of *Euphorus* in controlling *Sahlbergella*, but it is apparent that the parasite is inadequate in preventing this capsid from causing damage of great economic importance to cacao in West Africa. Unfortunately, investigations on the biology of *Euphorus* have been held up through inability to follow the life cycle in the laboratory. Mortality in the prepupal and pupal stages is almost 100 per cent.

No egg parasites of *Sahlbergella* or *Distantiella* have so far been found.

The predaceous " assassin " bugs, *Rhinocoris* spp., have been observed feeding on *Sahlbergella* and *Distantiella*. In the laboratory *R. loratus* showed no preference between these two capsids. " Assassin " bugs are omnivorous feeders and do not confine their attention to capsids alone.

It is frequently noticed that individual undamaged cacao trees in badly attacked areas are infested with the ant *Macromischoides* sp. and

this has given rise to the belief that the ant preys on the capsid and in certain circumstances controls it. Laboratory experiments failed to give supporting evidence, and in most cases capsid nymphs were completely ignored by the ant. The question is still being investigated and field experiments in connection with artificial colonization of cacao fields with *Macromischoides* sp. have been laid down.

Chemical Control.

The Institute has had the advantage of a visit from a member of Messrs. Pest Control Ltd. to examine and advise on the possibilities of insecticidal sprays and dusts and on mechanical means of applying these. As a result of collaboration with him detailed tests of Nicotine sulphate and other sprays and dusts were carried out in the laboratory and, on a small scale, in the field. These tests showed that no practical difficulty need be experienced in controlling any of the capsids, either as nymphs or as adults, provided the cacao trees were sufficiently small to be covered easily by the spray and provided there was a close and adequate supply of water. Difficulty was, however, experienced in destroying the eggs which are laid in the plant tissues.

Preliminary investigations were carried out, making use of D.D.T. One very great disadvantage this chemical possesses is its comparative insolubility in water (0·2–0·3 parts per million), which is, of course, the cheapest and most available diluent of insecticidal sprays. In the preliminary experiments carried out at Tafo the chemical was first dissolved in a vegetable oil and an emulsion made of this solution in water. The results obtained were encouraging and a definite residual action was obtained using 1 per cent. solution of D.D.T. (60 per cent. pure). Water dispersible pastes of D.D.T. and 666 (Gammexane) have recently been received and are under trial.

The absence of adequate spraying apparatus, whether hand or motor operated, has prevented proper field scale experiments. Hand-pressure spraying machines are on order.

Spraying against *Sahlbergella*—the capsid which attacks mature trees—will inevitably present a more formidable problem than spraying against *Distantiella*, which is mainly confined to young trees. We shall have a considerable acreage of young cacao both at Tafo and on the experimental substations where trials can be carried out on the effect of insecticidal sprays against *Distantiella*.

Cacao Resistant to Capsids.

Field observations show that certain trees growing in the midst of an area blasted by capsids escape major damage and it has been suggested that such trees are genetically resistant. Such a tree, S.C.1, was noticed at Asuansi, Gold Coast, and budwood was taken from it and budded on alternate plants in alternate rows of Amelonado cacao. The tree itself is a hybrid of the Trinitario complex.

Experiments to compare the two types of cacao in point of resistance or susceptibility were carried out in this plot. Comparable portions of

each type of cacao were caged and one capsid placed in each cage for a specific length of time. The number of feeding punctures were then counted. With *Sahlbergella*, the total of 24 such trials, and with *Distantiella*, the total of 27 trials, gave the following results :—

TABLE 9.

	SAHLBERGELLA.		*DISTANTIELLA.*	
	S.C.1.	*Amelonado.*	S.C.1.	*Amelonado.*
Number of Punctures ...	170	277	185	331

This experiment was repeated, but owing to feeding punctures being confluent in several instances, an estimated number based on the area damaged is given.

TABLE 10.

	SAHLBERGELLA.		*DISTANTIELLA.*	
	S.C.1.	*Amelonado.*	S.C.1.	*Amelonado.*
Estimated number of Punctures ...	29	33	20	61

These results give a very strong indication that *Sahlbergella* and *Distantiella* cause less damage to the Trinitario selection S.C.1 than to the common West African Amelonado. Further work is in progress, and we have 54 other clones selected for resistance to capsids.

IV. INTRODUCTIONS.

In order to increase the range of cacao material from which to select the best types for growing in West Africa, a collection of cacao varieties has been introduced from Trinidad and of other species of *Theobroma* from Brazil. The bulk of this collection was selected and dispatched by an officer of the Institute by air. All introduced pods were surface-sterilized before dispatch, and again on receipt at the Plant Quarantine Station in Accra, where seedlings were grown for at least six months. No sign of witches' broom disease was seen, and with few exceptions the growth of the plants has been satisfactory.

Table 11 gives a list of the types and the number of seedlings of each available for planting.

TABLE 11.

CACAO INTRODUCTIONS.

Type.	Female Parent.	Male Parent.	Total Pods.	Seedlings.
Criollo	Nicaraguan	?	2	63
,, ...	Venezuelan	?	2	33
,, ...	de Verteuil	?	1	22
,, ...	I.C.S.45	?	1	27
,, ...	I.C.S.56	I.C.S.85	1	37
,, ...	I.C.S.60	?	1	36
,, ...	I.C.S.85	?	1	6
,, ...	I.C.S.85	I.C.S.85	3	54
Total Criollo types... ...			12	278
Trinitario	I.C.S. 6	?	1	44
,, ...	I.C.S.70	?	1	19
,, ...	I.C.S.76	?	1	14
,, ...	I.C.S.76	Nanay	1	48
,, ...	I.C.S.80	?	1	31
,, ...	I.C.S.91	?	2	44
,, ...	I.C.S.93	?	2	30
,, ...	I.C.S.95	?	1	34
,, ...	deVerteuil 1	?	1	26
,, ...	,, 2	?	1	33
,, "Wild" Tobago ...	—	?	1	15
,, ,, Trinidad ...	—	?	2	24
,, Costa Rica (Green)	—	?	1	30
,, ,, ,, (Red) ...	—	?	1	23
,, Crinkle-leaf... ...	—	?	1	5
Total Trinitario types ...			18	420
Ecuador (doubtful affinities) ...	AM*	?	3	69
,, ...	B	?	1	37
,, ...	CL	?	1	29
,, ...	CLM	?	1	22
,, ...	JA	?	2	69
,, ...	LV	?	1	38
,, ...	LZ	?	1	40
,, ...	MOQ	?	1	37
Total Ecuador (doubtful affinities)			11	341
Lower Amazon.				
Brazilian	—	—	—	—
Maranhao	—	?	1	45
,, Surinam Wild ...	—	?	1	37
,, ,, ,, ...	—	Surinam Wild	1	49
Total Lower Amazon types			3	131

* Letters are Mr. F. S. Pound's (Senior Agronomist, Trinidad) abbreviations for different Estates in Ecuador. These were all selected for resistance to Witches' Broom.

TABLE 11—*continued.*

CACAO INTRODUCTIONS.

Type.	Female Parent.	Male Parent.	Total Pods.	Seedlings.
Upper Amazon	Ecuador (E)	?	1	42
,, ,, ...	,, (M)	?	1	11
,, ,, ...	,,	Ecuador (M)	3	62
,, ,, ...	Scavina	?	1	37
,, ,, ...	Morona	?	2	58
,, ,, ...	Nanay	?	4	159
,, ,, ...	,,	Nanay	4	170
,, ,, ...	,,	Parinari	2	83
,, ,, ...	,,	Iquitos Island	2	92
,, ,, ...	,,	Trinitario	1	—
,, ,, ...	,,	,, Crinkled	1	40
,, ,, ...	,,	I.C.S.85	1	22
,, ,, ...	Parinari	?	2	40
,, ,, ...	,,	Nanay	3	108
,, ,, ...	,,	Parinari	1	37
,, ,, ...	,,	Iquitos Island	1	32
,, ,, ...	Iquitos Island	?	2	107
,, ,, ...	,,	Nanay	4	179
Total Upper Amazon types			36	1,279

OTHER THEOBROMA SPECIES.

Species.	Total Pods.	Total Seedlings.
Microcarpum	7	22
Grandiflorum	2	34
Angustifolium	6	0
Speciosum	1	11
Subincanum	1	1
Obovatum	10	30
Herrania balaoense	2	23
,, *? albiflora*	1	20
,, *? mariae*	3	61

A portion of the *Th. cacao* material is being retained in the Accra Quarantine house for eventual dispatch to Nigeria. At the moment Nigeria has no suitable facilities for plant quarantine, and we consider these introductions should not leave Accra until the necessary precautions have been taken against the possibility of bringing disease intc Nigeria.

Budwood from I.C.S. clones introduced some years ago into Nigeria has been taken to Tafo for propagation.

V. EXPERIMENTAL PLOTS IN NATIVE FARMS.

One of the first problems affecting the West African cacao industry was to find out whether cacao could be re-established in those areas devastated by swollen-shoot disease. And once re-established, to ascertain whether the disease would again invade the farm, and if so at what stage and with what rapidity and whether control by rogueing would be effective. Information on these points will be very necessary; moreover, we have sufficient evidence from field observations to suggest that *Distantiella* may well be a limiting factor in the re-establishment of cacao even if swollen-shoot can be controlled. At the moment we consider chemical control the most promising method in combating *Distantiella*, but the details of such control can only be worked out in field experiments on a scale bigger than is practicable at the Institute's experimental station at Tafo.

The Institute was fortunate in already having one such field experiment, started by the Department of Agriculture in 1941, at Akwadum. Mention has been made of this station in connection with Virus Research. Additional field experiments have been commenced at Nankese 18 acres, Kukua 30 acres, Adunkwanta 20 acres. These were all cacao farms, most of the trees in which had been destroyed by swollen-shoot disease. After removing the remaining infected trees temporary shade was planted and cacao seed sown at stake in lines five feet apart. At Kukua and Adunkwanta it is proposed that half the area should be left in order to ascertain the time of ingress and rate of spread of swollen-shoot and *Distantiella*; on the other half, and at Akwadum and Nankese, every effort will be made to control this disease and pest. The field experiment plots thus give us some 60 acres of young cacao uniformly planted and of uniform age.

At Koransang, 20 acres of mature cacao surrounded by swollen-shoot diseased trees have been demarcated. Trees within the 20 acres which showed disease symptoms have been cut out and the vacancies caused thereby filled with seed sown at stake. The object of this experiment is to repeat the control measures adopted by the Institute at Tafo for maintaining mature cacao. With the exception of Akwadum, which is leased to the Department of Agriculture for 15 years, the land for the field experiments was put at the disposal of the Institute by the owners on a "gentleman's agreement," by which the Institute could carry out whatever work it liked while the owner, besides receiving a small annual rent, also gained any produce. In each instance the owner had asked the Institute to use the land for experimental purposes. These *ad hoc* arrangements will call for reconsideration since the death of an owner might complicate the agreements.

VI. SOIL SURVEYS.

The Soil Scientist arrived at Tafo in December, 1944, and is undertaking a rapid preliminary survey of the Gold Coast, Nigeria and Cameroons cacao areas. He will then be in a position to formulate detailed plans for carrying out intensive soil surveys.

VII. SOIL FERTILITY.

The Senior Chemist has been devoting half his time to the work of the Department of Agriculture and half to cacao investigations for the Institute.

The symptoms induced by a deficiency of minor elements are being studied in cacao grown in controlled nutrient solutions.

Iron deficiency has been of frequent occurrence in cacao grown in pots. Leaves exhibited varying degrees of chlorosis and marginal scorch ; in severe cases the terminal bud was killed and dwarfed shoots developed from secondary buds. Examples of such plants occurred among a number of batches of introduced cacao and other *Theobroma* species growing in the Accra Quarantine house. Here the iron deficiency appeared to be a simple case of lime-induced chlorosis brought about both by the presence of free calcium carbonate in the potting soil and by the use of municipal water limed to pH8·2.

Spraying with a 1 per cent. solution of ferrous sulphate caused no injury to the buds or young leaves and induced increased pigmentation within five days. Soil treatment with sulphuric acid followed by ferrous sulphate gave only partial success in restoring pigmentation to chlorotic plants.

Sickle Leaf.

Interest in this complaint has quickened because of the possibility of confusion with virus mosaic. Sickle leaf is characterized by the distortion which the name implies, by aberrations in pigmentation, and, in the most severe cases, by the development of necrotic patches. Sickle leaf has been induced by the application of cacao ash or an aqueous extract of the ash ; or by small amounts of potassium carbonate. Symptoms have also been developed by the addition of potassium sulphate to potted surface cacao soils of a reaction of pH7·6 or over.

Soil Moisture.

Soil moisture examinations were made during a period of extreme drought in February in young cacao plots in which either plantains or secondary growth of bush plants were grown as shade. There was no significant difference in surface soil moisture. In two other sets of young cacao plots shaded respectively by *Gmelina* and *Leucaena glauca* the former contained significantly less moisture in the surface soil, and this was confirmed by observation on the relative degree of defoliation of the two sets of cacao.

VIII. BOTANICAL STUDIES.

Selection.

No further selections for yield or quality have been made because selection is now confined to resistance against virus diseases or capsid pests. The progeny trials of trees selected for yield and quality have

been maintained, but considerable damage from capsids has occurred in certain plots. Of particular interest is the more vigorous growth of the Nigerian selection T.38 when compared with the Amelonado trees selected in the Gold Coast. Selection for tolerance to swollen-shoot or to *Sahlbergella* and *Distantiella* has been recorded elsewhere in this report.

Propagation.

Propagating bins for rooting cuttings were completed towards the end of the year. Using the technique evolved by the Imperial College of Tropical Agriculture, Trinidad, fair success was obtained. Experiments with root-producing substances are under way. During the dry season we have been getting approximately 50 per cent. rooting, which is not so satisfactory as we wish, but heavy losses on hardening off are even less satisfactory. Propagation by rooting cuttings is considered an essential step in obtaining genetically uniform material, on which to carry out strictly controlled experiments on virus strains and on other lines of work.

Rapid multiplication of certain selected trees has been made by budding. This provides an easy and reliable method of propagation. Large numbers of seedlings have been planted to act as stocks and to supply material for laboratory needs.

IX. MYCOLOGY.

Investigations were started on the causes of dieback of cacao which could not be attributed to capsid attack or to virus disease. *Calonectria rigidiuscula* was found to be associated with these conditions and the fungus is being studied.

C. rigidiuscula also appears to be associated with the development of capsid lesions.

X. AGRONOMY.

The yield per acre of cacao from the station dropped slightly during the twelve months under review.

TABLE 12.

Season.	Acreage of mature cacao.	Yield dry cacao per acre.
1938/39	69·19	808
1939/40	69·19	783
1940/41	73·69	788
1941/42	70·44	795
1942/43	66·44	749
1943/44	63·94	720
1944/45	63·81	690

Experiments on young and mature cacao were maintained, but do not call for special consideration in this report. Twelve acres of food

crops were grown for sale to the staff and six acres of bananas planted to supply suckers for use as shade in future experimental cacao plantings.

Station Development.

In addition to maintaining existing buildings, roads, and habitation areas at Tafo the following buildings were erected during the period under review :—

(1) Nine temporary houses for European Officers.

(2) Large Store of swish construction with shingled roof.

(3) Ten insect-proof houses.

(4) Two batteries of 18 bin propagators.

(5) One battery of 9 hardening-off bins of the same size as (4).

(6) Two plant barns for hardening-off cuttings and seedlings.

(7) One garage for lorry, of sundried brick construction.

(8) One Temporary Office for Agronomists and staff.

(9) Alterations to the 5 permanent bungalows, by the addition of covered verandahs, the floor space being increased by about 30 per cent.

(10) Alterations to the offices and laboratories.

Rate of flow readings in a stream were recorded at a point three-and-a-half miles from the habitation area with the object of assessing the potential water supply.

O. J. VOELCKER,

Director of Cacao Research.

	MONTHLY MEANS—1938–43.											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Average Shade Maximum	90·7	92·8	93·5	92·7	92·0	89·0	86·3	86·3	87·3	89·5	90·0	90·0
Average Shade Minimum	60·2	62·8	66·7	66·8	67·2	66·2	66·2	64·8	66·8	66·8	65·7	63·3
Mean Relative Humidity (9 a.m. G.M.T.)	86·6	84·7	80·7	81·4	82·3	84·5	85·6	85·5	84·1	82·3	81·1	83·5
Mean Relative Humidity (3 p.m. G.M.T.)	52·7	48·7	48·0	52·2	56·3	62·0	61·2	59·5	69·5	68·6	65·7	62·2
Rainfall in inches	1·74	3·80	4·36	6·11	9·00	7·84	4·83	2·86	5·54	8·46	6·51	2·70
Number of wet days	4·7	6·3	10·5	12·2	15·7	18·7	11·7	12·2	16·3	17·0	11·8	7·3
	1944.											
Average Shade Maximum	89	92	91	95	92	90	87	85	88	89	90	91
Average Shade Minimum	59	58	66	66	67	68	68	68	68	67	66	61
Mean Relative Humidity (9 a.m. G.M.T.)	85·7	82·1	82·3	78·0	78·4	82·1	83·0	84·2	84·8	81·4	78·4	79·0
Mean Relative Humidity (3 p.m. G.M.T.)	57·2	50·3	60·3	58·5	57·9	70·5	72·0	70·1	69·8	68·5	62·7	58·1
Rainfall in inches	2·35	2·64	6·86	6·16	2·68	6·74	2·02	2·98	4·67	6·89	3·20	1·93
Number of wet days	5	6	15	10	8	14	13	13	18	15	10	7

ANNUAL RAINFALL FIGURES—1938–44.

1938	1939	1940	1941	1942	1943	1944
Inches 55·33	Inches 84·96	Inches 56·92	Inches 56·59	Inches 59·45	Inches 69·09	Inches 49·12

WEST AFRICAN CACAO RESEARCH INSTITUTE—TAFO.

STATEMENT OF FINANCIAL POSITION AS AT 31st MARCH, 1945.

LIABILITIES.

	£ s. d.	£ s. d.
CREDITORS :—		
Advances.		
Gold Coast Government		30,000 0 0
Honourable Director of Agriculture, Accra :—		
Period 1st April, 1944 to 31st July, 1944 ...	25,760 14 6	
Period 1st August, 1944 to 31st March, 1945 ...	55 0 0	
	25,815 14 6	
Less—Refunded, viz. :— £ s. d.		
Period 1st April, 1944 to 31st July, 1944 ... ... 15,410 11 3		
Period 1st August, 1944 to 31st March, 1945 ... ... 205 0 0		
	15,615 11 3	
		10,200 3 3
Commissioner of Lands, Accra :—		
Period 1st August, 1944 to 31st March, 1945		187 2 3
UNCLAIMED WAGES		1 13 3
DEFICIT AND SURPLUS ACCOUNT :—		
Revenue—Period 1st April, 1944 to 31st July, 1944 ... ... —		
Expenditure 9,919 9 0		
	9,919 9 0	
Revenue—Period 1st August, 1944 to 31st March, 1945 ... 570 17 11		
Expenditure 27,560 1 8		
	26,989 3 9	
Debit—*per Contra*	36,908 12 9	
		£40,388 18 9

ASSETS.

	£ s. d.	£ s. d.
DEBTORS :—		
Staff Advances		275 11 4
STOCKS :—		
Unallocated Stores and Materials on Hand ...		2,600 14 0
CASH :—		
	£ s. d.	
In Hand—Imprest Account ...	100 0 0	
At Bank on Current Account—		
Bank of British West Africa Limited—Koforidua	504 0 8	
		604 0 8
DEFICIT AND SURPLUS ACCOUNT, *per Contra* ...		36,908 12 9
		£40,388 18 9

(Sgd.) M. GREENWOOD,
AG. Director of Cacao Research.

We certify that we have audited the Accounts and Records of the Research Institute and have obtained all the information and explanations we have required. In our opinion, and subject to our Report of even date attached, the above Statement of Position correctly discloses the floating Liabilities and Assets of the Institute and the financial state of affairs at 31st March, 1945, according to the best of our information and the explanations given to us and as shown by the books of the Institute.

ACCRA, 30*th April*, 1945.

(Sgd.) CASSLETON ELLIOTT & Co.,
Auditors.